

EVALUATION OF n + 53Cr CROSS SECTIONS FOR THE ENERGY
RANGE 1.0E-11 to 150 MeV

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22 Oct. 1997

This evaluation provides a complete representation of the nuclear data needed for transport, damage, heating, radioactivity, and shielding applications over the incident neutron energy range from 1.0E-11 to 150 MeV. The discussion here is divided into the region below and above 20 MeV.

INCIDENT NEUTRON ENERGIES < 20 MeV

Below 20 MeV the evaluation is based completely on the ENDF/B-VI.5 (Release 2) evaluation by D. Hetrick, D. Larson, N. Larson, and C. Y. Fu.

INCIDENT NEUTRON ENERGIES > 20 MeV

The ENDF/B-VI Release 2 evaluation extends to 20 MeV and includes cross sections and energy-angle data for all significant reactions. The present evaluation utilizes a more compact composite reaction spectrum representation above 20 MeV in order to reduce the length of the file. No essential data for applications is lost with this representation.

The evaluation above 20 MeV utilizes MF=6, MT=5 to represent all reaction data. Production cross sections and emission spectra are given for neutrons, protons, deuterons, tritons, alpha particles, gamma rays, and all residual nuclides produced ($A > 5$) in the reaction chains. To summarize, the ENDF sections with non-zero data above $E_n = 20$ MeV are:

MF=3 MT= 1 Total Cross Section
MT= 2 Elastic Scattering Cross Section
MT= 3 Nonelastic Cross Section
MT= 5 Sum of Binary (n,n') and (n,x) Reactions

MF=4 MT= 2 Elastic Angular Distributions

MF=6 MT= 5 Production Cross Sections and Energy-Angle Distributions for Emission Neutrons, Protons, Deuterons, Tritons, and Alphas; and Angle-Integrated Spectra for Gamma Rays and Residual Nuclei That Are Stable Against Particle Emission

The evaluation is based on nuclear model calculations that have been benchmarked to experimental data, especially for n + Cr52 and p + Cr52 reactions (Ch97). We use the GNASH code system (Yo92), which utilizes Hauser-Feshbach statistical, preequilibrium and direct-reaction theories. Spherical optical model calculations are used to obtain particle transmission coefficients for the Hauser-Feshbach calculations, as well as for the elastic neutron angular distributions.

Cross sections and spectra for producing individual residual nuclei are included for reactions. The energy-angle-correlations for all outgoing particles are based on Kalbach systematics (Ka88).

A model was developed to calculate the energy distributions of

all recoil nuclei in the GNASH calculations (Ch96). The recoil energy distributions are represented in the laboratory system in MT=5, MF=6, and are given as isotropic in the lab system. All other data in MT=5, MF=6 are given in the center-of-mass system. This method of representation utilizes the LCT=3 option approved at the November, 1996, CSEWG meeting.

Preequilibrium corrections were performed in the course of the GNASH calculations using the exciton model of Kalbach (Ka77, Ka85), validated by comparison with calculations using Feshbach, Kerman, Koonin (FKK) theory [Ch93]. Discrete level data from nuclear data sheets were matched to continuum level densities using the formulation of Ignatyuk et al. (Ig75) and pairing and shell parameters from the Cook (Co67) analysis. Neutron and charged-particle transmission coefficients were obtained from the optical potentials, as discussed below. Gamma-ray transmission coefficients were calculated using the Kopecky-Uhl model (Ko90).

SOME Cr-SPECIFIC INFORMATION CONCERNING THE EVAL.

The neutron total cross section was evaluated at energy grid points by using the least-squares code GMA (Po81) taking account of the new data measured by Dietrich et al. for natural Cr (Di97). The results were transformed to the Cr-53 cross section according to the $A^{*(2/3)}$ law, i.e., by multiplying by a factor of 1.012076.

The neutron optical model potential derived for n + Cr-52 was used for calculation of DWBA cross sections.

The transmission coefficients calculated for the n + Cr-52 evaluation were employed for all the n + Cr-50 evaluation channels, by multiplying by a factor of 1.01278, i.e., a ratio of $A^{**(2/3)}$ between Cr-53 and Cr-52.

The Cr-52 transmission coefficients were calculated by using the following potentials:

For the neutron channel, the newly-searched potential for n + Cr-52, as described in File 1 of the n + Cr-52 evaluation, was used.

For the proton channel, a combination of 2 potentials was used :
below 40 MeV : Becchetti-Greenlees (Be69)
above 40 MeV : Madland medium energy potential (Ma88)

The proton reaction cross section and transmission coefficients below 40 MeV were multiplied by a factor of 0.845 to make the agreement with the measured proton reaction cross section (Ca96) better, and also to make the connection to higher energy values smoothly.

For deuterons, the Lohr-Haeberli (Lo74) global potential was used; for alpha particles the McFadden-Satchler (Mc66) potential was used; and for tritons the Becchetti-Greenlees (Be71) potential was used. The He-3 channel was ignored.

No direct collective inelastic scattering was considered.

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24053 = TARGET 1000Z+A (if A=0 then elemental)

1 = PROJECTILE 1000Z+A

Nonelastic, elastic, and Production cross sections for A<5 projectiles in barns:

Energy	nonelas	elastic	neutron	proton	deuteron	triton	helium3	alpha	gamma
2.000E+01	1.295E+00	9.285E-01	2.173E+00	1.012E-01	2.313E-02	1.592E-03	0.000E+00	3.350E-02	4.040E+00
2.200E+01	1.266E+00	9.474E-01	2.134E+00	1.285E-01	2.926E-02	2.192E-03	0.000E+00	3.440E-02	4.150E+00
2.400E+01	1.238E+00	1.005E+00	2.157E+00	1.654E-01	3.484E-02	2.948E-03	0.000E+00	3.486E-02	3.898E+00
2.600E+01	1.208E+00	1.056E+00	2.204E+00	2.128E-01	3.994E-02	3.660E-03	0.000E+00	3.547E-02	3.435E+00
2.800E+01	1.179E+00	1.123E+00	2.227E+00	2.629E-01	4.473E-02	4.298E-03	0.000E+00	3.581E-02	3.066E+00
3.000E+01	1.152E+00	1.186E+00	2.252E+00	2.976E-01	4.712E-02	4.862E-03	0.000E+00	3.715E-02	2.807E+00
3.500E+01	1.098E+00	1.329E+00	2.293E+00	3.491E-01	5.424E-02	5.977E-03	0.000E+00	4.242E-02	2.602E+00
4.000E+01	1.054E+00	1.435E+00	2.299E+00	4.071E-01	5.965E-02	6.726E-03	0.000E+00	4.461E-02	2.503E+00
4.500E+01	1.015E+00	1.496E+00	2.322E+00	4.546E-01	6.266E-02	7.316E-03	0.000E+00	4.674E-02	2.397E+00
5.000E+01	9.808E-01	1.519E+00	2.358E+00	4.925E-01	6.443E-02	7.782E-03	0.000E+00	4.989E-02	2.300E+00
5.500E+01	9.501E-01	1.511E+00	2.384E+00	5.332E-01	6.552E-02	8.235E-03	0.000E+00	5.360E-02	2.251E+00
6.000E+01	9.225E-01	1.480E+00	2.413E+00	5.770E-01	6.439E-02	8.706E-03	0.000E+00	5.789E-02	2.172E+00
6.500E+01	8.978E-01	1.431E+00	2.438E+00	6.128E-01	6.516E-02	9.201E-03	0.000E+00	6.226E-02	2.108E+00
7.000E+01	8.759E-01	1.369E+00	2.449E+00	6.433E-01	6.593E-02	9.735E-03	0.000E+00	6.684E-02	1.993E+00
7.500E+01	8.565E-01	1.307E+00	2.470E+00	6.703E-01	6.644E-02	1.031E-02	0.000E+00	7.117E-02	1.951E+00
8.000E+01	8.394E-01	1.235E+00	2.489E+00	6.975E-01	6.689E-02	1.096E-02	0.000E+00	7.548E-02	1.902E+00
8.500E+01	8.244E-01	1.159E+00	2.512E+00	7.258E-01	6.757E-02	1.183E-02	0.000E+00	8.098E-02	1.843E+00
9.000E+01	8.114E-01	1.090E+00	2.532E+00	7.531E-01	6.834E-02	1.288E-02	0.000E+00	8.670E-02	1.817E+00
9.500E+01	8.000E-01	1.015E+00	2.554E+00	7.793E-01	6.902E-02	1.403E-02	0.000E+00	9.258E-02	1.804E+00
1.000E+02	7.902E-01	9.505E-01	2.580E+00	8.053E-01	6.837E-02	1.528E-02	0.000E+00	9.850E-02	1.756E+00
1.100E+02	7.745E-01	8.245E-01	2.636E+00	8.518E-01	7.081E-02	1.825E-02	0.000E+00	1.111E-01	1.723E+00
1.200E+02	7.629E-01	7.135E-01	2.692E+00	8.913E-01	7.280E-02	2.123E-02	0.000E+00	1.225E-01	1.684E+00
1.300E+02	7.547E-01	6.172E-01	2.754E+00	9.324E-01	7.616E-02	2.469E-02	0.000E+00	1.338E-01	1.655E+00
1.400E+02	7.492E-01	5.402E-01	2.798E+00	9.657E-01	7.872E-02	2.756E-02	0.000E+00	1.424E-01	1.606E+00
1.500E+02	7.467E-01	4.714E-01	2.842E+00	1.006E+00	8.066E-02	3.082E-02	0.000E+00	1.513E-01	1.592E+00

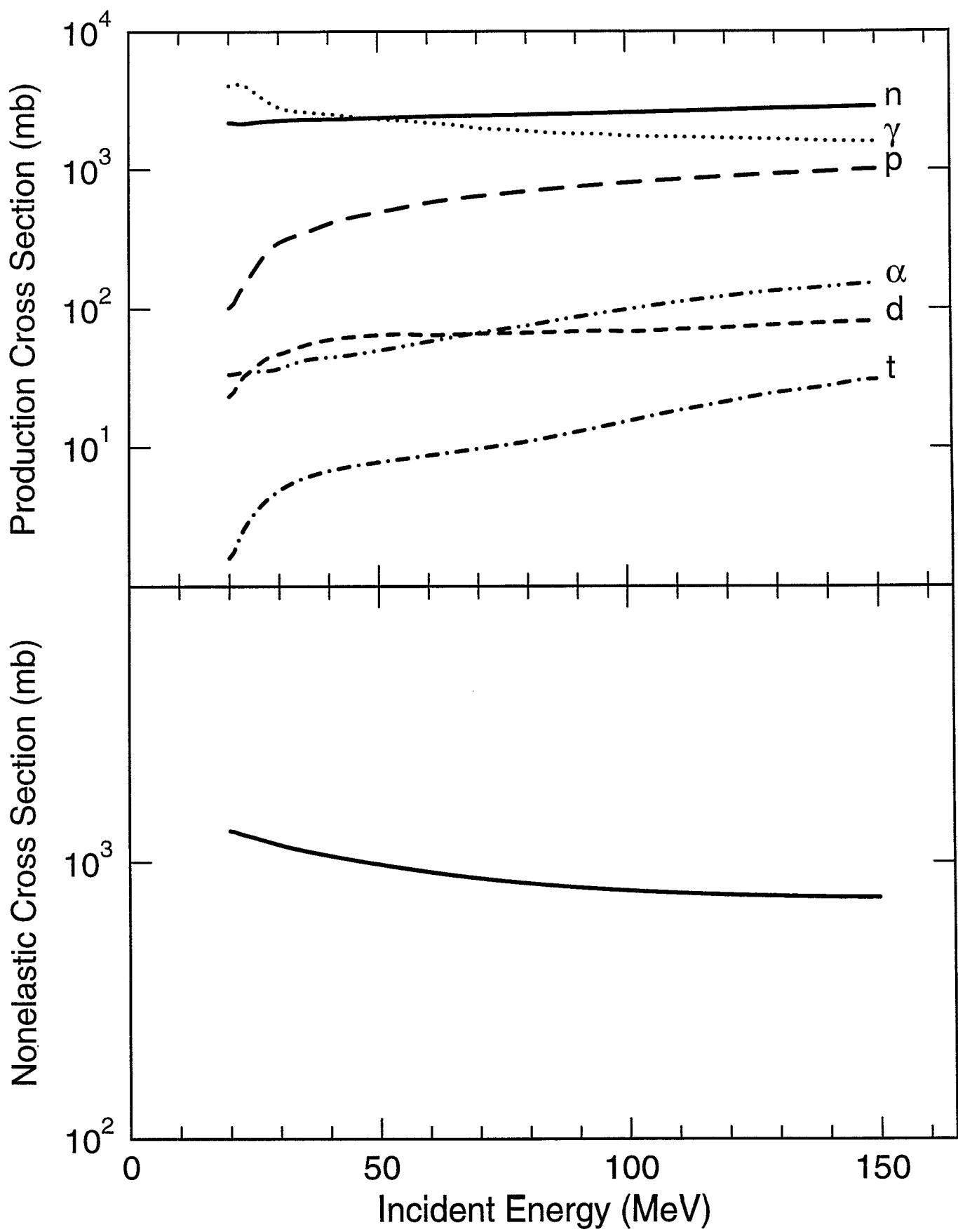
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1 = PROJECTILE 1000Z+A

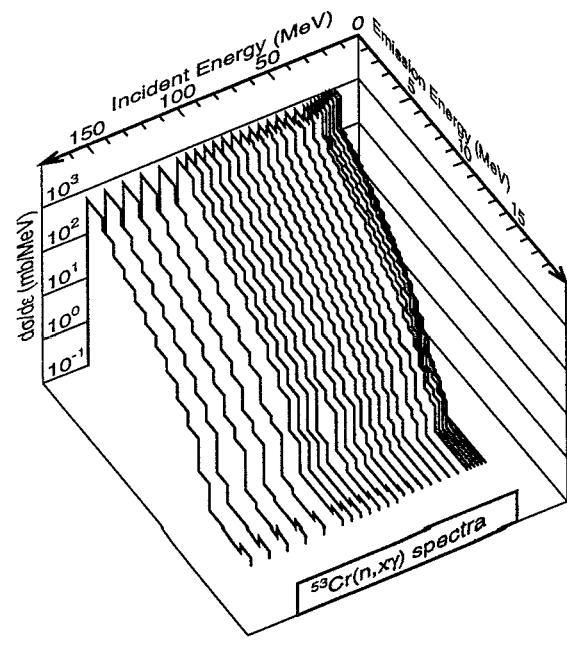
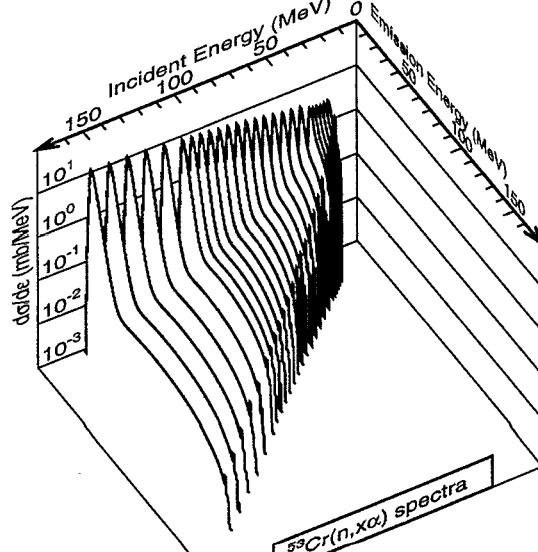
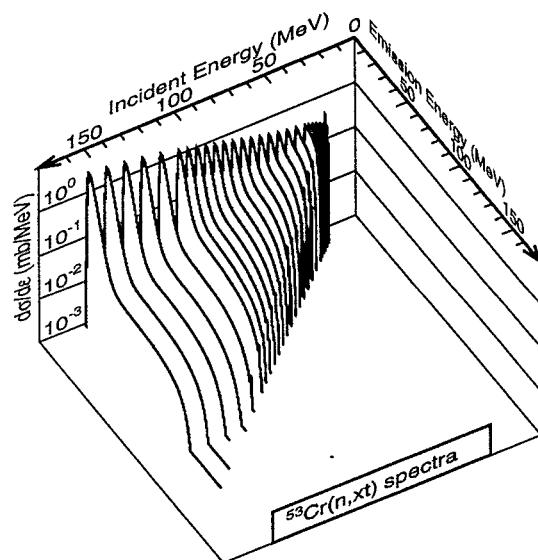
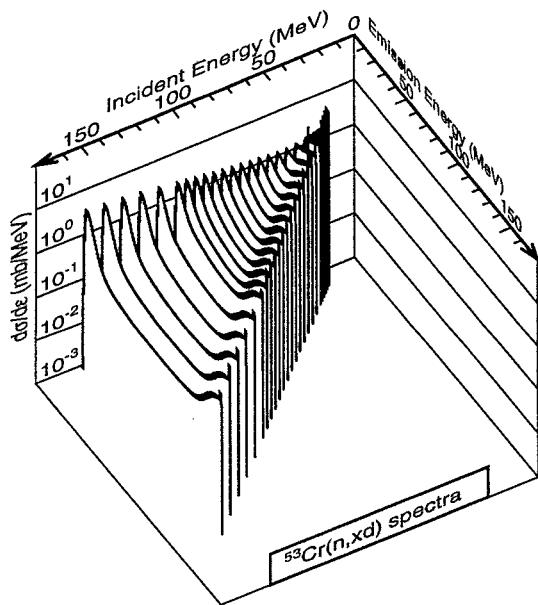
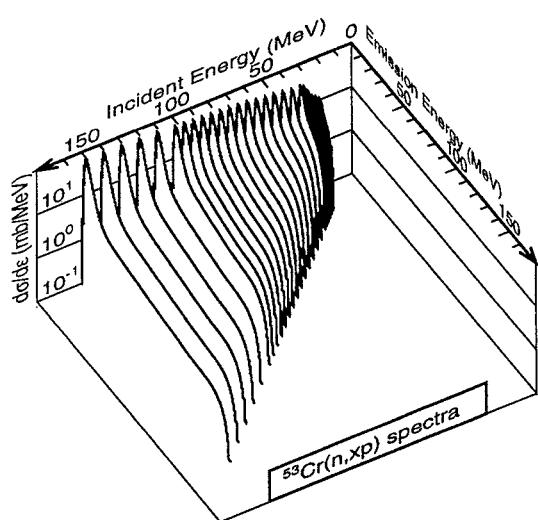
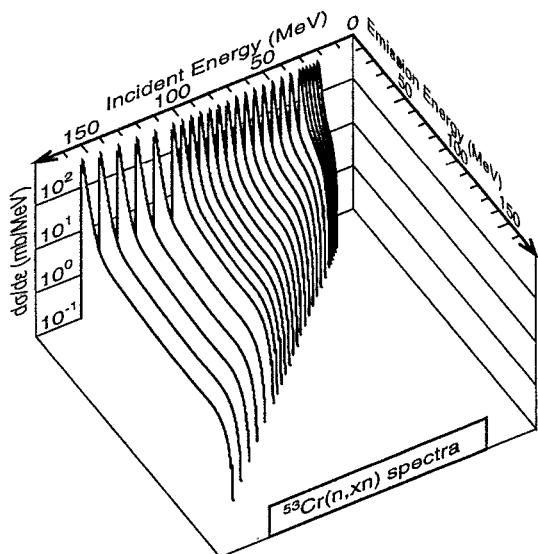
Kerma coefficients in units of f.Gy.m^2:

Energy	proton	deuteron	triton	helium3	alpha	non-rec	elas-rec	TOTAL
2.000E+01	1.322E-01	3.384E-02	1.751E-03	0.000E+00	6.307E-02	1.069E-01	2.578E-02	3.636E-01
2.200E+01	1.751E-01	4.894E-02	2.717E-03	0.000E+00	6.747E-02	1.133E-01	2.794E-02	4.354E-01
2.400E+01	2.264E-01	6.545E-02	4.076E-03	0.000E+00	7.070E-02	1.190E-01	3.003E-02	5.156E-01
2.600E+01	2.898E-01	8.312E-02	5.549E-03	0.000E+00	7.371E-02	1.242E-01	3.102E-02	6.074E-01
2.800E+01	3.608E-01	1.022E-01	7.081E-03	0.000E+00	7.599E-02	1.287E-01	3.188E-02	7.067E-01
3.000E+01	4.329E-01	1.151E-01	8.612E-03	0.000E+00	7.960E-02	1.325E-01	3.222E-02	8.010E-01
3.500E+01	6.031E-01	1.599E-01	1.234E-02	0.000E+00	9.071E-02	1.423E-01	3.182E-02	1.040E+00
4.000E+01	7.875E-01	2.095E-01	1.564E-02	0.000E+00	9.804E-02	1.506E-01	3.028E-02	1.292E+00
4.500E+01	9.714E-01	2.540E-01	1.865E-02	0.000E+00	1.048E-01	1.577E-01	2.829E-02	1.535E+00
5.000E+01	1.150E+00	2.935E-01	2.118E-02	0.000E+00	1.127E-01	1.642E-01	2.612E-02	1.763E+00
5.500E+01	1.330E+00	3.282E-01	2.364E-02	0.000E+00	1.215E-01	1.695E-01	2.396E-02	1.997E+00
6.000E+01	1.519E+00	3.436E-01	2.591E-02	0.000E+00	1.311E-01	1.736E-01	2.187E-02	2.215E+00
6.500E+01	1.703E+00	3.747E-01	2.801E-02	0.000E+00	1.410E-01	1.776E-01	1.987E-02	2.444E+00
7.000E+01	1.890E+00	4.040E-01	2.992E-02	0.000E+00	1.515E-01	1.815E-01	1.800E-02	2.675E+00
7.500E+01	2.075E+00	4.322E-01	3.179E-02	0.000E+00	1.612E-01	1.841E-01	1.636E-02	2.901E+00
8.000E+01	2.262E+00	4.590E-01	3.360E-02	0.000E+00	1.713E-01	1.864E-01	1.480E-02	3.127E+00
8.500E+01	2.449E+00	4.842E-01	3.558E-02	0.000E+00	1.835E-01	1.888E-01	1.336E-02	3.354E+00
9.000E+01	2.631E+00	5.098E-01	3.767E-02	0.000E+00	1.964E-01	1.916E-01	1.212E-02	3.579E+00
9.500E+01	2.818E+00	5.321E-01	3.979E-02	0.000E+00	2.096E-01	1.942E-01	1.093E-02	3.805E+00
1.000E+02	3.014E+00	5.310E-01	4.205E-02	0.000E+00	2.232E-01	1.955E-01	9.952E-03	4.015E+00
1.100E+02	3.395E+00	5.746E-01	4.686E-02	0.000E+00	2.519E-01	2.005E-01	8.225E-03	4.477E+00
1.200E+02	3.792E+00	6.086E-01	5.114E-02	0.000E+00	2.789E-01	2.046E-01	6.849E-03	4.942E+00
1.300E+02	4.189E+00	6.553E-01	5.561E-02	0.000E+00	3.062E-01	2.155E-01	5.749E-03	5.427E+00
1.400E+02	4.609E+00	7.039E-01	5.891E-02	0.000E+00	3.284E-01	2.278E-01	4.920E-03	5.933E+00
1.500E+02	5.052E+00	7.239E-01	6.304E-02	0.000E+00	3.518E-01	2.395E-01	4.226E-03	6.435E+00

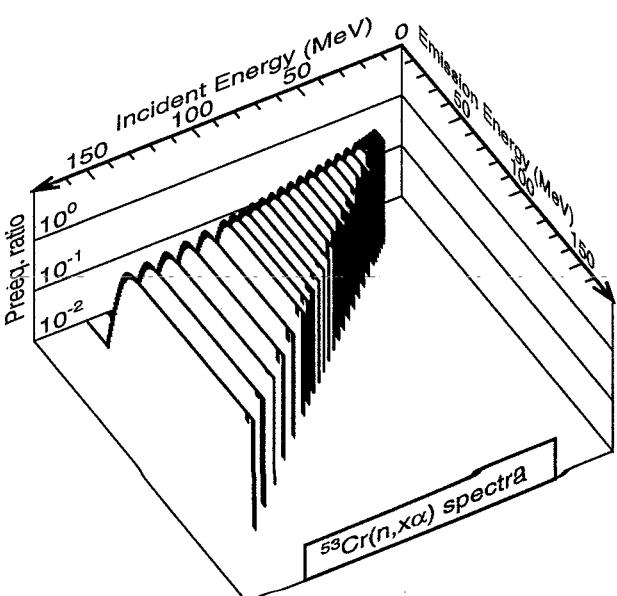
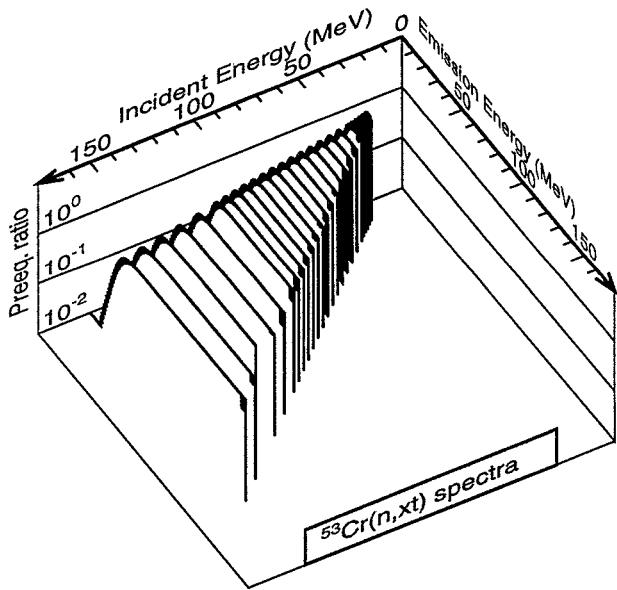
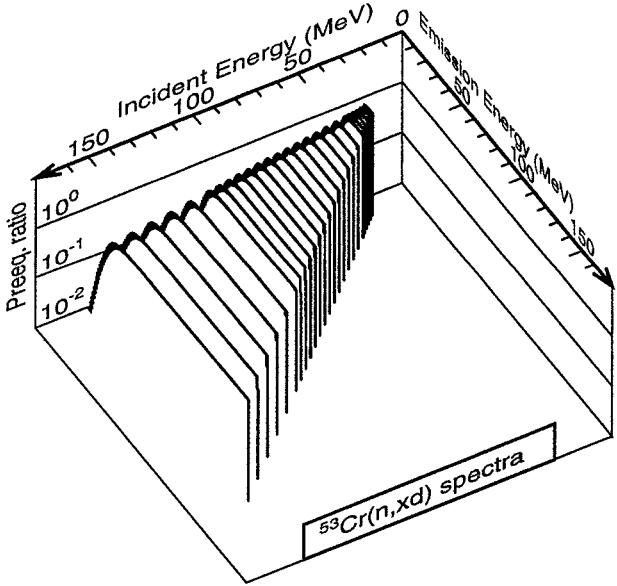
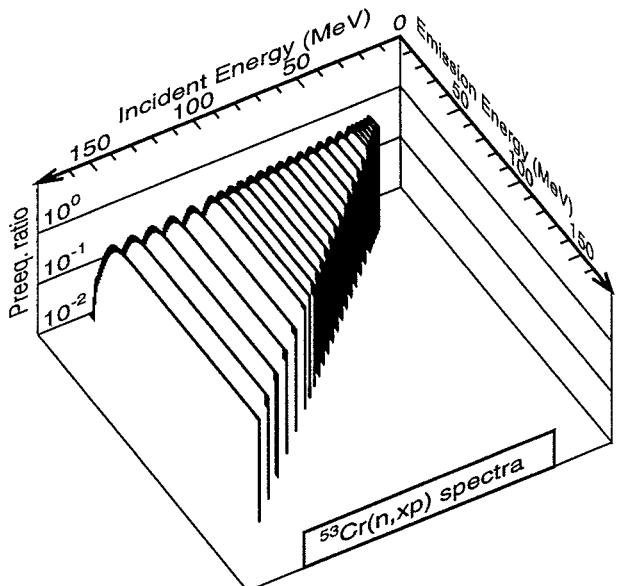
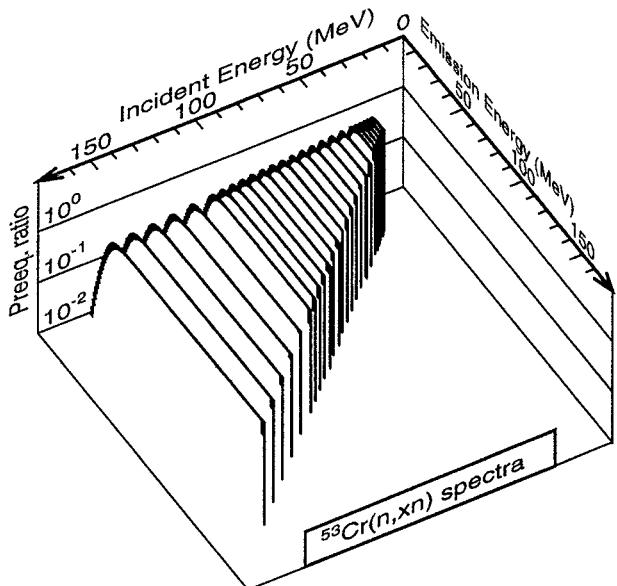
$n + {}^{53}\text{Cr}$ nonelastic and production cross sections



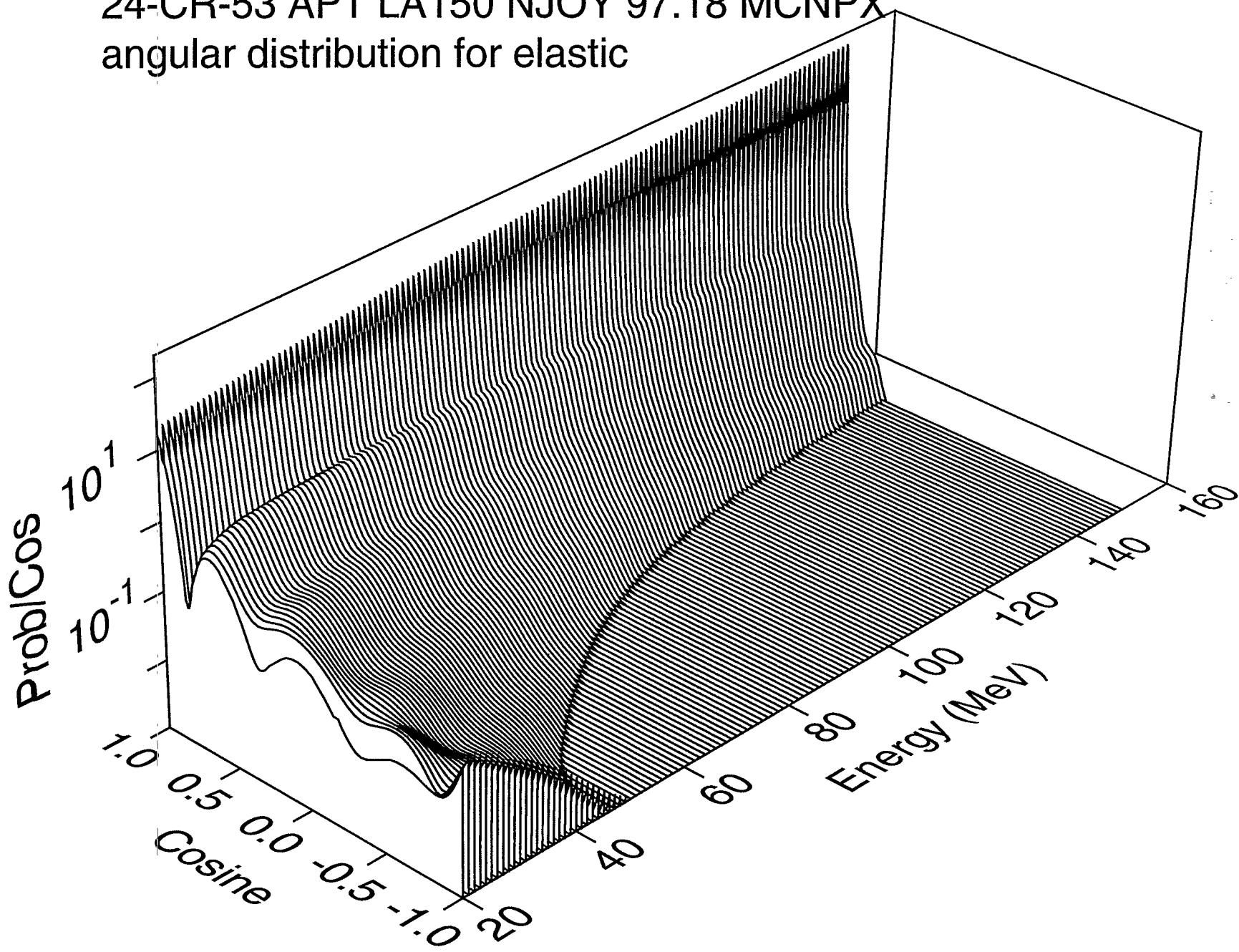
$n + {}^{53}\text{Cr}$ angle-integrated emission spectra



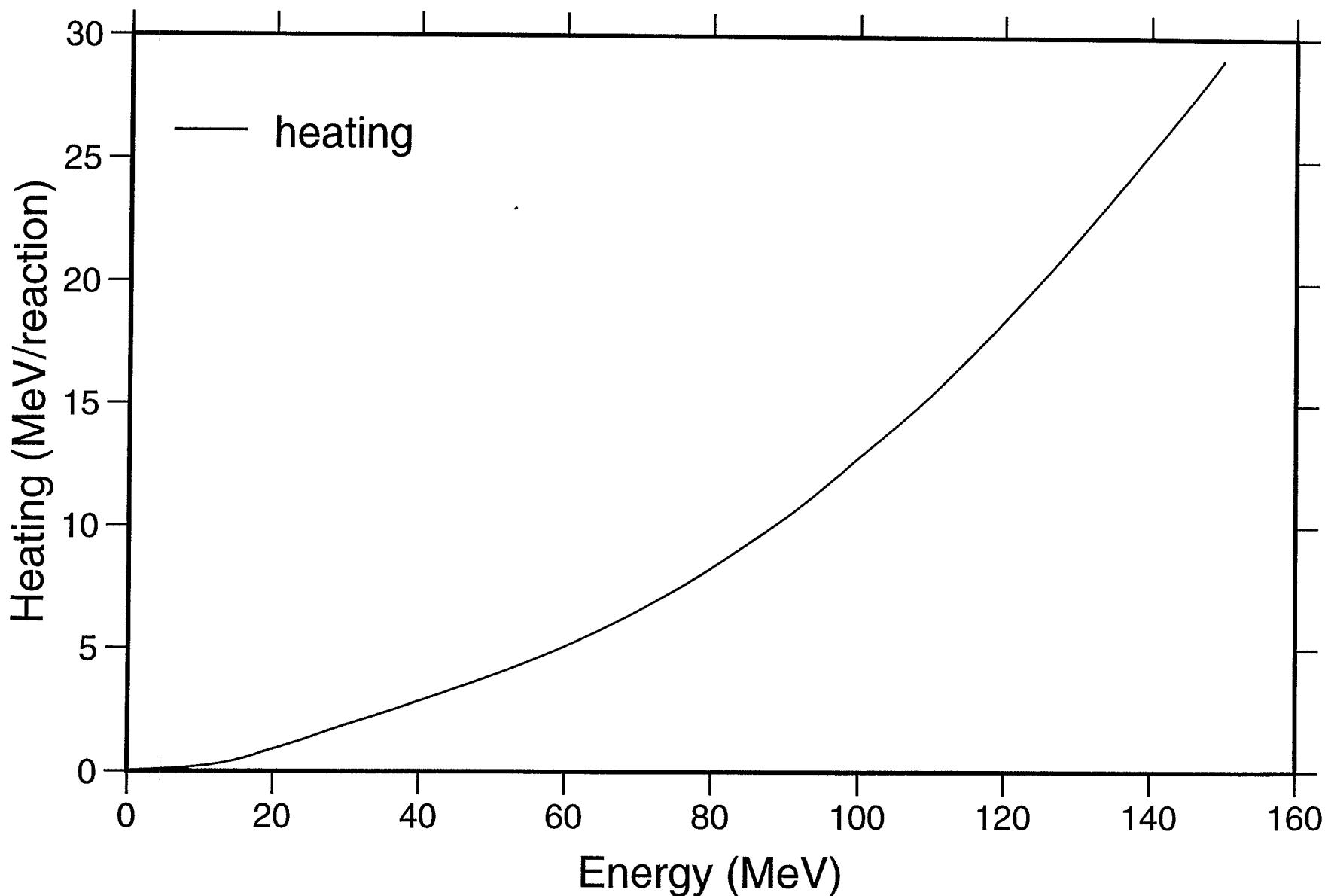
$n + {}^{53}\text{Cr}$ Kalbach preequilibrium ratios



24-CR-53 APT LA150 NJOY 97.18 MCNPX
angular distribution for elastic



24-CR-53 APT LA150 NJOY 97.18 MCNPX
Heating



24-CR-53 APT LA150 NJOY 97.18 MCNPX

Damage

